



AEROSPACE INFORMATION REPORT

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Fuel Flow Rates for Jet-Powered Commercial Aircraft Taxi Operations

RATIONALE

This SAE Aerospace Information Report (AIR) provides aviation environmental modelers with an enhanced method for estimating jet-powered commercial aircraft fuel flow during taxi operations. Flight data recorder information from actual operations of a variety of representative aircraft types were used to inform the proposed enhancements.

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Documents

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1. SCOPE

This SAE Aerospace Information Report (AIR) summarizes prior empirical findings (AIAA 2018-3991; Chati, 2018) to recommend a modified baseline fuel flow rate model for jet-powered commercial aircraft during taxi operations on the airport surface that better reflects operational values. Existing standard modeling approaches are found to significantly overestimate the taxi fuel flow rate; therefore, a modified multiplicative factor is recommended to be applied to these existing approaches to make them more accurate. Results from the analysis of operational flight data are reported, which form the basis for the modeling enhancements being recommended.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

AIR6183 Procedures for the Calculation of Airplane Fuel Consumption

DuBois, D. and Paynter, G., "Fuel Flow Method2' for Estimating Aircraft Emissions," SAE Technical Paper 2006-01-1987, 2006, <https://doi.org/10.4271/2006-01-1987>.

2.1.2 AIAA Publications

Available from American Institute of Aeronautics and Astronautics, 1801 Alexander Bell Drive, Suite 500, Reston, VA 20191-4344, Tel: 703-264-7500, www.aiaa.org.

AIAA 2018-3991 Enhancing Aircraft Fuel Burn Modeling on the Airport Surface

2.1.3 FAA Publications

Available from Federal Aviation Administration, 800 Independence Avenue, SW, Washington, DC 20591, Tel: 866-835-5322, www.faa.gov.

DOT-VNTSC-FAA-22-04 Aviation Environmental Design Tool (AEDT) - Version 3e - Technical Manual

2.1.4 ICAO/EASA Publications

Available from European Union Aviation Safety Agency, Konrad-Adenauer-Ufer 3, D-50668 Cologne, Germany, Tel: +49 221 8999 000, www.easa.europa.eu.

ICAO Aircraft Engine Emissions Databank

2.1.5 Other Publications

Chati, Y.S., "Statistical Modeling of Aircraft Engine Fuel Burn," Ph.D. Thesis, Department of Aeronautics and Astronautics, Massachusetts Institute of Technology, Cambridge, MA, USA, 2018, <https://dspace.mit.edu/handle/1721.1/115658>.

Nikoleris, T., Gupta, G., and Kistler, M., "Detailed Estimation of Fuel Consumption and Emissions During Aircraft Taxi Operations at Dallas/Fort Worth International Airport," Transportation Research Part D, Vol. 16, No. 4, pp. 302–308, 2011, <https://doi.org/10.1016/j.trd.2011.01.007>.

2.2 Acronyms

A4A	Airlines for America
AEDT	Aviation Environmental Design Tool
AIAA	American Institute for Aeronautics and Astronautics
AIR	Aerospace Information Report
BFFM2	Boeing Fuel Flow Method 2
FAA	Federal Aviation Administration
FDR	Flight Data Recorder
ICAO	International Civil Aviation Organization
OLS	Ordinary Least Squares

3. INTRODUCTION

Models of aircraft taxi operations on the airport surface and associated fuel flow and emissions are used for several purposes, such as assessing the impacts of changes to operational procedures, airport infrastructure and fleet mixes, and conducting environmental studies. A standard way of modeling jet-powered commercial aircraft taxi fuel flow (for example, in the FAA's Aviation Environmental Design Tool (AEDT); refer to DOT-VNTSC-FAA-22-04) is to assume a constant engine-specific thrust level (and resulting fuel flow rate) determined by applying a correction factor for installation effects to engine manufacturer certification data (refer to ICAO Aircraft Engine Emissions Databank). However, the resulting estimate of the fuel flow rate can be significantly different than actual characteristics during operational conditions for a given aircraft (Nikoleris et al., 2011). This difference can be because of a variety of factors, such as the age of the engine (as the engine gets older the amount of fuel it burns changes), pilot technique (such as "riding the brakes" instead of throttling down the engines when coming to a stop), and location on the airports surface (such as in the ramp area compared to active taxiways). This AIR analyzes operational data to develop more realistic fuel flow models for taxi operations to improve the accuracy of airport surface fuel and emissions calculations.

4. CURRENT TAXI FUEL FLOW MODELING

Figure 1 shows a typical fuel flow rate profile (post-pushback and engine start) during taxi operations. This profile is from a common narrow-body twin engine commercial aircraft, and although the fuel flow magnitudes vary with aircraft type, the shape is representative of most jet-powered commercial aircraft. It can be seen that the fuel flow rate profile can be divided into two distinct regions: baseline regions (two of which are identified using dashed-line ovals) and fuel flow spike regions (one of which is identified using a dotted-line oval). The baseline fuel flow regions are characterized by almost constant (low variation) fuel flow rate over extended time intervals under normal moving taxi conditions, and the fuel flow spike regions correspond to the periods of increased thrust needed to re-start movement after a period of being stopped.